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UAT MOPS

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Temporary Address for ADS-B

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SUMMARY
This paper outlines a concept for use of a temporarily assigned address for ADS-B. Use of such an address could be either to provide total anonymity or anonymity to all but ATC.

1. Assumptions

1. It is desirable to preserve a “1200 code” style of operation with ADS-B for cases where no ATC services are desired by the airspace user.

2. It is desirable to allow ADS-B users that require ATC services to employ a *temporarily* assigned ADS-B address (for flight duration) rather than a *permanent* airframe assigned address at their option.

3. Users desiring basic IFR services would not need to broadcast a call sign/flight id as this could be provided to the controller via ATC automation. These users may or may not be eligible for certain “pair-wise” air-air procedures as intended in the ADS-B MASPS.

4. Reports can be generated from received ADS-B messages without the need for guaranteed unique addressing (e.g., for message assembly).

2. The Concept

1. If a user desires a temporary address, they select a temporary address option at unit startup time or during flight. A randomly generated field of bits is created based on a seed from e.g., the least significant bits of the lat/lon fields at the location where the selection of a temporary address was made. A separate address qualifier bit is used to distinguish a temporarily assigned address from a permanent (24 bit ICAO) address.

2. If no ATC services are desired, no further action is needed.

3. If user desires ATC service, a procedure would be required to allow the ATC system to correlate the temporarily generated address with the filed flight plan information. Two possibilities are listed below[1]:
   a) If departing an airport with a control tower, the ground or local controller establishes the target's randomly generated address association with flight data (i.e., the "tag up").
   b) If the user is a pop-up in the system, the user provides ATC the temporary address, an IDENT action, or some discriminating state vector information on initial contact. This allows the ATC system to correlate the temporary address to the flight data information (analogous to assigning beacon code and declaring "radar contact" currently).

3. What if temporary (random) addresses conflict?

a) <u>What is the probability of observing no address conflicts</u>? This depends on the number of aircraft using random addresses that are observed via ADS-B at one time and the number of bits devoted to the random address. The following table gives a summary assuming a completely random address number generation:

[1] Current policy in Capstone is to require the permanent address for "radar-like" services.

Number of random address aircraft observed via ADS-B at any given time	**Probability of observing <u>no</u> address conflicts amongst these aircraft** (2^{24} random address space)[2]
1,000	0.97
100	0.9997

This table indicates a potential problem for the simplest CDTI target update processing: one that employs no tracker but instead relies on unique addressing for display maintenance. This could be overcome at the expense of extra logic that checks for address conflicts and performs a simple proximity check that distinguishes the tracks of targets with address conflicts.

b) <u>What is the probability of a given user selecting an address that will not conflict with anyone in ADS-B range during a flight?</u>: The table below shows this.

Number of aircraft with random addresses that pass within ADS-B range during a flight	**Probability that a given user's random address is <u>not</u> involved in address conflict with these aircraft** (2^{24} random address space)[3]
10,000	0.9994
1,000	0.99994
100	0.999994

[2] If we let *m* be the size of the random address space (2^{24}) and *n* be the number of aircraft with random addresses that are observed, then the probability of not seeing any conflict of addresses amongst the *n* aircraft is

$$P = \frac{m \cdot (m-1)\Lambda\ (m-n+1)}{m^n}.$$

This reduces to

$$P = \left(1-\frac{1}{m}\right)\left(1-\frac{2}{m}\right)\Lambda\ \left(1-\frac{n-1}{m}\right)$$

By taking logarithms, we obtain approximately, using $Log_e(1-x) \approx -x$ for small x,

$$\log_e(P) = -\left(\frac{1}{m}+\frac{2}{m}+\Lambda\ +\frac{n-1}{m}\right)$$

$$P = e^{-\left(\frac{1}{m}\cdot\frac{n(n-1)}{2}\right)}$$

[3] The probability of any single random address in an address space *m* conflicting with any other in a set *n* is $P = \frac{n}{m}$

Although far from an everyday occurrence, at some point any given user may be involved in an address conflict. Air-air, this is not a problem as the “conflict with self” is easily resolved. It is however observable to ATC. If our user is receiving ATC service and the address conflict is a problem for ATC, the user could simply be instructed to regenerate a new random address. This is similar to current operations where users may be instructed to change transponder code during flight (there are only 4096 of these).

4. Summary and Conclusions

A concept for temporary (flight duration) addressing of ADS-B messages has been described. It is suggested that this same concept of randomly generated, self-assigned, addresses be adopted in the UAT MOPS.

This random, self-assigned address approach both improves privacy and eliminates the administrative complexity relative to an approach that supports anonymity through special address administration techniques. The main objective of the temporary address is to preserve the equivalent of “1200-style” transponder operation. However, it has been shown here that it may also be viable for basic IFR operations. This may be an important consideration should broadcast of identity information become a general privacy concern as ADS-B use becomes more widespread.